Chart of 1,270 North Polar Stars.

The following are the positions and magnitudes of the 38 stars on Argelander's chart, which are shown as *white circles* on the accompanying engraved photo-chart (Plate IV.).

Magnitude.	Right Ascension. h m s	Declination. ° ′ ″	Magnitude.	Right Ascension. h m s	Declination. ° ′ ″
9·5	0 11 5	89 36 2	9·5	12 0 23	89 26 3
9·2	1 17 35	0 2	8·8	12 59 20	28 3
8·8	1 49 36	29 2	8·7	13 3 53	8 7
9·4	1 50 57	23 6	9·4	13 25 6	32 6
9·5	1 51 58	13 3	9·5	15 3 47	24 2
9·4	2 16 43	0 6	9·0	15 14 45	40 9
9·3	3 11 12	4 3	9·5	15 44 3	55 1
9·5	3 53 49	0 5	9·5	15 45 16	2 8
9·1	4 49 39	27 1	8·7	17 21 38	18 4
9·5	5 43 44	6 0	9·4	18 7 27	43 8
9·5	5 57 3	3 6	9·3	18 42 30	9 5
9·1	6 17 38	37 9	9·5	19 29 17	38 0
7·0	7 3 40	1 8	9·5	19 37 46	12 9
9·5	7 14 2	1 0	9·5	19 45 0	27 5
9·2	7 27 50	1 6	9·3	19 56 5	14 3
9·5	8 58 47	39 4	9·3	20 13 29	45 9
9·0	10 26 21	32 0	9·5	21 8 21	31 7
8·9	11 8 27	43 9	9·3	22 6 40	48 0
9·5	11 9 11	32 9	9·0	23 21 18	0 8

On a Compensating Pendulum. By Richard Inwards.

The pendulum about to be described must not be taken as novel in all its parts. So much has been done that such entire novelty would now be impossible. But what I hope is that the general arrangement with its many new features may result in a substantial improvement on existing forms.

In accurate pendulums in which the temperature compensation is obtained by the expansion in contrary directions of tubes of zinc and steel, there has always been a great difficulty in at once apportioning the respective lengths of the rods or tubes used for the purpose.

This difficulty arises in a great measure from the fact that no two specimens of the metals can be readily obtained having exactly the same coefficient of expansion. Particularly with the zinc is

this the case, as one may see by consulting the different horological and mechanical text-books, where widely different figures are given as based on the experiments of various investigators.

Even in the best clocks, where the proportions of the tube-lengths have been most carefully adjusted by theory, it is often found necessary to dismount the pendulum in order to alter the length of the zinc tube.

In the Westminster clock this has, I believe, been done on at least two occasions, when pieces of zinc had to be inserted in order to bring the compensation to its present apparently perfect condition.

The zinc tube in the usual pendulum is under powerful compression in having to sustain as a pillar the whole weight of the bob, and it may be that it requires some time before its atoms settle down to a steady rate of expansion under this heavy strain. It may also be that the tube shortens a little by bending in the middle. In any case, the remedy involves stopping the clock and making up the pendulum again.

Many contrivances have been suggested for the purpose of meeting this difficulty, but all involve some disadvantages. That of Ellicott has a number of pivots and joints to be adjusted, while the plan proposed by our own esteemed Fellow, Mr. Buckney, has the disadvantage of carrying a considerable piece of surplus zinc, and of the necessity of entirely retiming the clock after the alteration. A plan proposed on somewhat similar lines by myself* is open to the same objections.

By the method now proposed the alteration in the proportionate lengths of the zinc and steel can be made at once while the clock is going, and if erroneously altered can be corrected at any time, also without stopping the clock.

This is to be done by transferring the compensating rods or tubes to the fixed part of the clock.

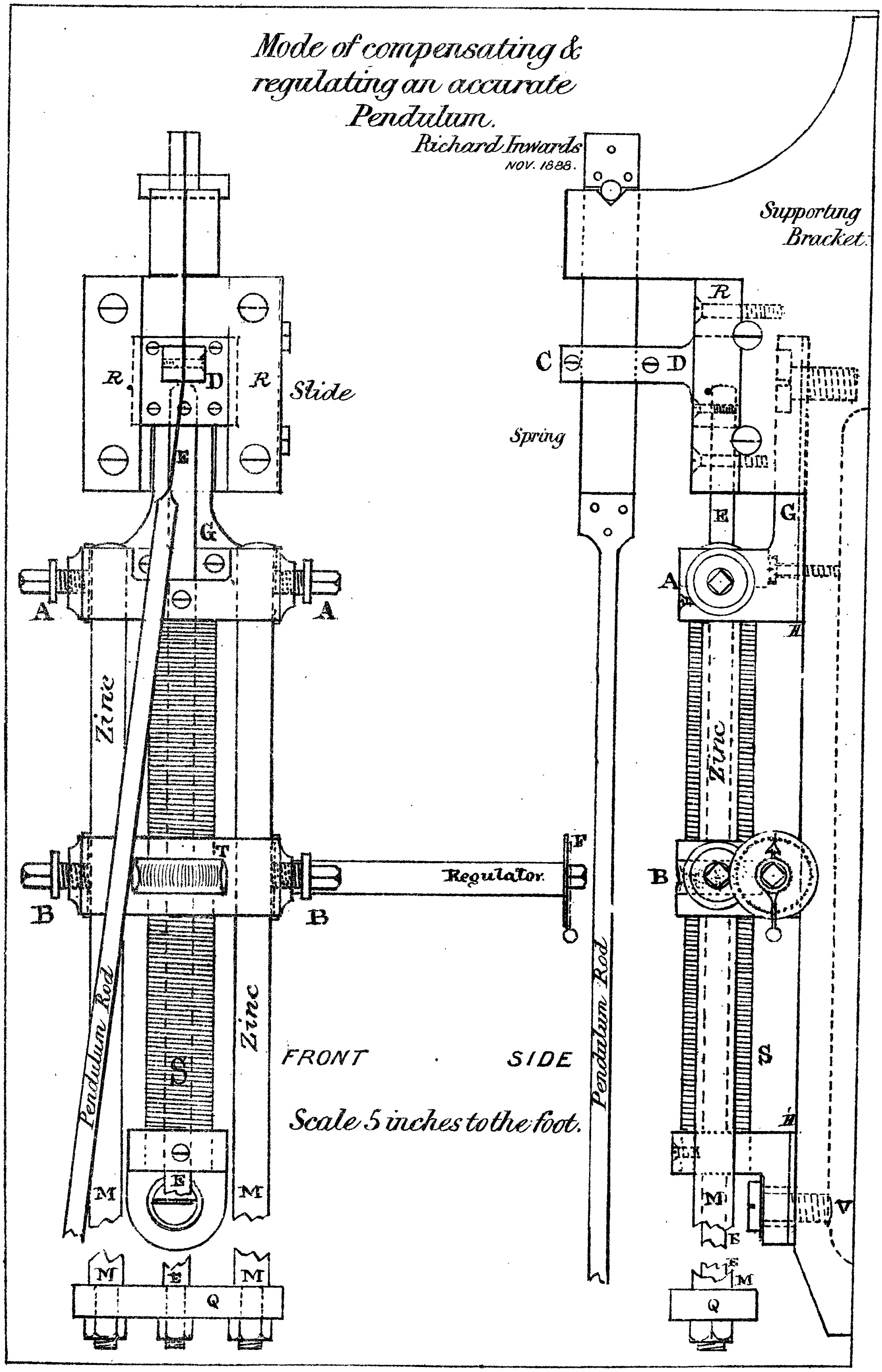
In the accompanying drawings the means of carrying out the proposed changes are depicted.

The woodcut in black shows the general arrangement of the pendulum, while the whole-page plate gives elnarged front and side views of the upper portion. The letters refer to the same parts in each diagram.

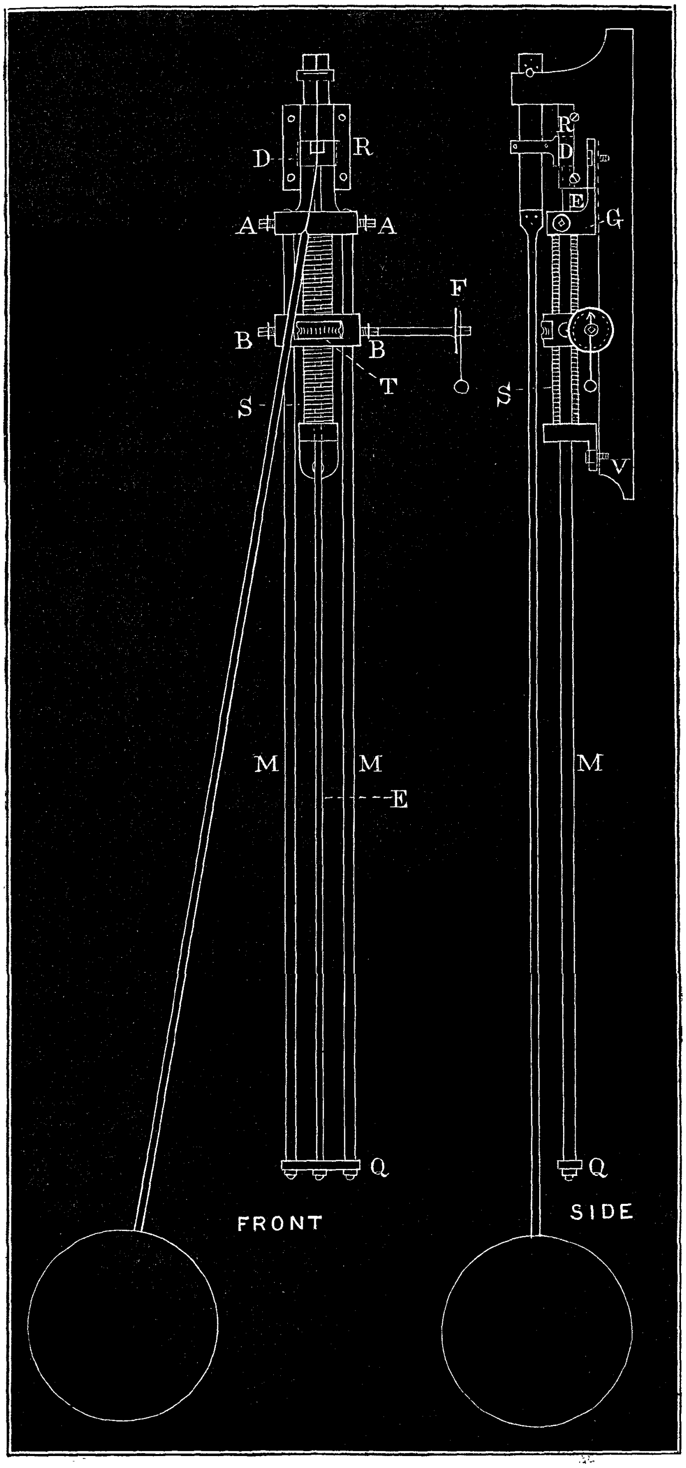
It will be seen that the pendulum is supported in the usual way from a strong cast iron projection, and is suspended by a spring of somewhat greater length than is customary.

About the middle of the spring it is grasped by a clip consisting of two arms D, which are adjusted to embrace it with sufficient closeness to hold it firmly, but loose enough to allow of movement in a vertical direction. There are screws to regulate this pressure, and I should propose to add a lining of wood or leather to the clips where they bear upon the pendulum spring. The arm D is fixed to a block which moves vertically between two slides, very similar to a smaller copy of those on a lathe slide

* *Horological Journal*, September 1886.


Mode of compensating & regulating an accurate Pendulum.
Richard Inwards
NOV. 1888.
Supporting Bracket.
Slide
Spring
Zinc
Zinc
Zinc
Regulator.
Pendulum Rod
Pendulum Rod
FRONT
SIDE
Scale 5 inches to the foot.
A
B
C
D
E
F
G
M
Q
R
S
T
V

rest. The slide has setting screws, and ought to admit of no horizontal motion whatever. It may be remarked in passing



that there is a great distinction in steadiness between this plan and that which has been often proposed, and in which the whole

pendulum support is moved so as to pull up the spring between the fixed chops, and in which case the weight of the pendulum is carried by a movable support instead of a fixed one.

In the present plan, by the further addition to the clips of a spring stiffer than the pendulum spring, and with a similar one on the side of the sliding block D, all possibility of the smallest lateral tremor would be cut off. Another advantage of these additional springs would be that the clips would slightly yield, and so override any small impediment such as dust or a spot of rust either on the pendulum spring or on the fixed part of the slide.

The sliding block D is attached to the end of a steel rod E of small diameter (as it has scarcely any strain to bear), and of about 30 inches long, and which passes down at the back of the pendulum-rod to a point a little above the level of the bob. Here it is fixed to the middle of a bar Q, which at its ends is made fast to the two zinc rods or compensating bars MM. These are about 29 inches in length, of which about 26 inches are acting on the pendulum. The zinc rods are firmly fixed at B to a block carrying in its centre a worm-wheel of 60 notches, T.

This worm-wheel, which is a kind of nut, turns on a fixed screw S (of 18 threads to the inch), firmly attached to the supporting bracket, and prevented from turning round.

The tangent screw actuating the wheel or nut T is behind it (not seen in the drawing). The axis of the tangent screw is prolonged to F, where it carries a dial of 32 divisions, and forms the regulating apparatus by which the timing of the clock is done, as well as making such alterations in the proportions of the lengths of zinc and steel as may be found necessary.

It will be seen that if the wheel T is turned it must rise or fall on the fixed screw S, and so through the medium of the zinc and steel rods raise or depress the sliding block moving on the pendulum spring above, and so altering the length of the pendulum. This is the proposed timing adjustment, and it will be found that one division of the regulating dial F will correspond to an alteration in rate of about one second per month. This is sufficiently delicate to obviate the necessity of adding small weights to the pendulum. The adjustment is made while the clock is going, and can also be used as a means for temporarily accelerating or retarding the clock.

A mechanical friend of great experience says that in altering this dial, say, to the right one division, it should first be turned a quarter of a turn to the left, and then brought one degree forward from where it stood before. This eliminates an error which might arise from slip or from hesitancy in moving.

Now to alter the proportion of zinc in the pendulum nothing more is necessary than to *first* tighten the binding screws AA (which must always be loose at other times), and then to slacken the screws BB. The effect of this is to release the regulator

from all connection with the pendulum, and make the zinc rods practically a part of the fixed bracket or support. Then by turning the regulating dial the effect will be that the worm-wheel T simply travels up or down the fixed screw, and changes the position of the binding screws B (now loose) with respect to the zinc rods. When this position has been altered so as to add or take away sufficient of the length, the screws B must be tightened while A A must be loosened (or perhaps better taken away till wanted).

It will be seen on carefully studying this plan that the upper part of the steel rod E is balanced as regards expansion by the expansion in a contrary direction of the support G and that of the part of the screw S above the tangent wheel.

G must therefore be of steel, so must S, and it is well that they should be of uniform thickness, say a quarter of an inch, so as to take up heat at equal rates.

The piece G is separated from the planed bed of the bracket by slips of bone (H, H′ on plate), with the object of allowing it to behave independently of the heavier cast-iron bracket, as regards expansion. Of course the lower screw V must pass through an oval hole, and may be kept up to a working contact by placing what is known as a spring washer or bent disc of steel underneath the head of the screw.

If these suggestions are, as I hope, practical, a great many minute sources of error in the pendulum will be got rid of by this form of construction. The pendulum itself will be brought almost to its ideal form, a mere ball of lead supported by a thin stem or wire. The resistance of the air to the pendulum rod will be reduced to a minimum. The proper proportion of zinc to steel can be at once restored, even after the minute displacement which occurs in timing. No useless weight will be carried. The clock need never be stopped except for cleaning or removing, and its rate and compensation can be altered even to the most minute degree while it is going.

The zinc used should be subjected to boiling and freezing before being attached to the pendulum, especially if in the form of drawn rods or tubes.

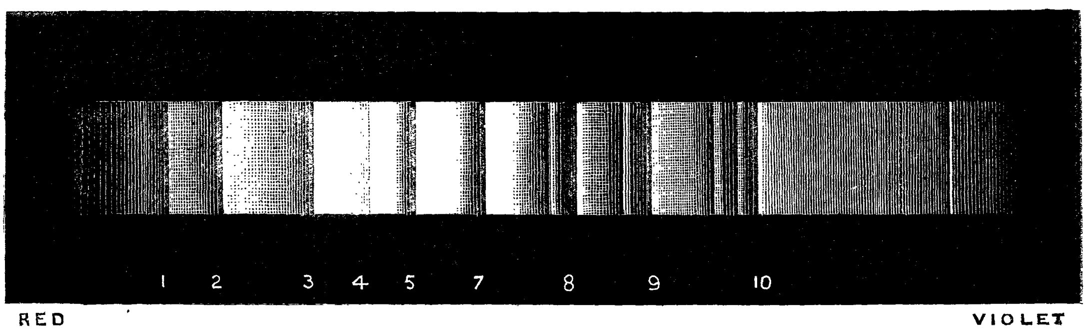
All these seem small matters, but it is with the "next to nothings" that we have now to deal, in striving to add the last perfections to our already nearly perfect timekeepers.

20 *Bartholomew Villas, N.W.:*
1888, *November* 8.

On the Spectra of R Cygni and Mira Ceti and some Stars with probably similar Spectra. By Rev. T. E. Espin.

R Cygni.—On August 13 a very bright line, apparently F, was visible in the spectrum of this star. The line was subsequently seen on several nights, and was measured and confirmed by Dr. Copeland at Dun Echt.

Mira Ceti.—During the maximum of this star the colour was very pale yellow; as soon as the maximum was passed the colour gradually inclined to orange. The accompanying drawing gives the appearance of the spectrum on October 23 in strong moonlight, and on October 30 on a dark sky, when the star had faded considerably. The observation of October 30 only added one new detail to the spectrum; this was the fact that band No. 8 in Dr. Dunér's nomenclature was really divided into two. Band No. 9 is also broken up into at least two, and band No. 10 into three. Whether these interferences in the bands are due to bright lines I am unable definitely to say.



Spectrum of *Mira Ceti,* 1888, October 23, 30.

The numbers refer to Dr. Dunér's bands.

Further away in the violet there is a brilliant line which may be the γ hydrogen line. The beauty of the spectrum is beyond anything I have seen. The spectrum was observed with a direct-vision prism before an eyepiece magnifying 200 times. By altering the distance between the prism and the eyepiece increased length of spectrum is obtained at pleasure. With the prism close to the eyepiece the spectrum of α *Orionis* consists of the usual III. type bands; by moving the prism six inches or so away from the eyepiece the bands are resolved into innumerable lines.

Since Professor Pickering discovered the bright lines in *Mira Ceti* and in Mr. Gore's star in *Orion,* I have examined very many